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DEVELOPMENT OBJECTIVES

## Basic Research in Precise Measurement

1. Introduction - These objectives describe the background, concept and requirements of a government sponsored program of basic research in precise measurement as it relates to mensuration techniques, procedures, and equipment in the imagery exploitation processes.

2. Background - The design of measuring systems used in the exploitation of reconnaissance imagery utilize many different approaches and employ a wide variety of instrumentation to obtain the measured value. The basic characteristic of the measuring instruments may be optical, mechanical, electronic, or any combination of these. The measuring systems may incorporate high performance optical systems, special illumination sources, and may require sophisticated environmental control.

Whatever the nature of the imagery mensuration problem may be, intelligent development, selection and use of measurement techniques and equipment depends on a broad knowledge of what is available and how the performance of the measuring equipment may be described in terms of the mensuration task to be accomplished. Both the new equipment under development and the basic instruments in use can be used as devices for the presentation and development of the general techniques and principles needed in measurement instrumentation. In general, the concepts developed in basic research of precise measurement will be useful in treating any mensuration devices that may be developed in the future.

3. Concept - This basic research program is directed toward the investigation and development of principles, techniques and instrumentation necessary to achieve the precision required in the imagery mensuration process. The research is to be concerned with investigating the factors affecting the standard of measurement, the types of instrument used for measuring, and the environment in which the measurements are made.

The program will not delve into the factors affecting the person making the measurements or the evaluation of specific computer data reduction programs.

4. General Description - The objective of this research program is: to investigate the basic conditions and circumstances that influence the accuracy and precision of measuring engines, to analyze film characteris-

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bles as they apply to the mensuration problem, and to generate specifications to be incorporated into development of future mensuration equipment.

The goal of this basic research is to obtain reliable information and recommendations as to improving and developing measurement systems commensurate with proposed acquisition systems and intelligence requirements.

This goal will be accomplished through: a literature search, an investigation of instrumentation requirements, the creation of analytical and experimental models, and a limited amount of breadboarding.

## 5. Detailed Objectives

### 5.1 Review of Previous Work and Literature

5.1.1 Review the results of the several related research programs that have been sponsored by the Government. Typical examples of these programs that have been recently completed or are presently underway are as follows:

- 5.1.1.1 Automatic Stereo Scanning
- 5.1.1.2 In-House Precise Measurement Study
- 5.1.1.3 Image Analysis
- 5.1.1.4 Precision Stereo Comparator

5.1.2 Perform an intensive literature search of available information on dimensional metrology, measuring engines, environmental control, vibrations dampening, light sources, etc. as it may be applied to measurements in imagery exploitation.

### 5.2 Review Present Mensuration Equipment and Techniques

5.2.1 The effect of viewing systems upon the mensuration process.

- 5.2.1.1 Anamorphic effects
- 5.2.1.2 Field of view
- 5.2.1.3 Effect of curvature of field
- 5.2.1.4 Effect of viewing through film base
- 5.2.1.5 Magnification vs accuracy of measurement

5.2.2 The effect of viewing illumination on the mensuration process.

- 5.2.2.1 White light as opposed to near monochromatic light
- 5.2.2.2 General vs high intensity spot
- 5.2.2.3 Effects of the amount of light at the eye, the color temperature, etc. on the accuracy of measuring and precision of pointing.

5.2.3 Study film hold down systems and determine their effects upon measurements.

5.2.3.1 Vacuum hold down systems, porous glass, grid pattern of channels, etc.

5.2.3.2 Glass plate hold down, thickness required, loss in resolution and contrast.

5.2.3.3 Clear Plastic Membrane with vacuum header.

5.2.3.4 Film Chip Hold down systems.

5.2.4 Film dimensional changes while on the mensuration equipment.

5.2.4.1 Changes in duplicate positive film over small areas (0.5  $\mu$ m).

5.2.4.2 Changes caused by the film hold down system.

5.2.4.3 Changes caused by the film transport system.

5.2.4.4 Changes caused by the lighting and film cooling system.

5.2.5 Measuring engine accuracy attainable with:

5.2.5.1 Shaft encoders

5.2.5.2 Linear Scales

5.2.5.3 Interferometers

5.2.5.4 Other measuring systems

5.2.6 Investigate type of reticles in use on monoscopic and stereoscopic measuring instruments.

5.2.6.1 Cross hairs, point light sources, black dots, colored reticles, etc.

5.2.6.2 Determine the most desired reticle size as referenced to the film plane.

5.2.6.3 Review the effect of positioning the reticle at various positions in the optical train.

5.2.7 Operator controls in pointing for monoscopic and stereoscopic measurements.

5.2.7.1 Handwheels, joystick, track balls, airbearing carriages, etc.

5.2.7.2 What is best for various degrees of precision (0.1, 0.5, 1.0, 2.5  $\mu$ m)?

5.2.7.3 Operator pointing vs auto correlation.

5.2.8 Appraise the optical system, the measuring engine, the operator controls, the viewing illumination, etc. as an integrated package in relation to the measuring task to be performed.

5.3 Investigate the mensuration requirements as related to  
compressed imagery systems

5.3.1 Determine what changes in measurement instrumentation  
and techniques will be required to accommodate color photography.

5.3.1.1 Recommendations as to light sources and color  
temperature

5.3.1.2 Viewing systems performance on color imagery.  
Will there be a depth of focus problem at higher magnification?

5.3.1.3 What is the best method of holding this imagery  
flat against the film platen?

5.3.1.4 What are the limitations of a stereo correlation  
unit on color imagery?

5.3.1.5 Specify the modifications that could be made to  
existing mensuration equipment to adequately handle color  
imagery.

5.3.1.6 Can additive color or false color be used for  
precise mensuration.

5.3.1.7 Define the specifications that should be included  
in future mensuration equipment for color imagery.

5.3.2 Investigate the mensuration techniques that might be  
used on near real-time systems.

5.3.2.1 What are the problems involved in obtaining  
monoscopic and stereoscopic measurements from a vidicon  
type display?

5.3.2.2 What accuracies are attainable?

5.3.2.2.1 Is it acceptable for precise photogram-  
metric type measurements?

5.3.2.2.2 Is it suitable for comparative type  
measurements?

5.4 Environmental Control Required for Precise Measurement and  
Comparative Measurements

5.4.1 Temperature and humidity control required for film  
stability.

5.4.2 Temperature, humidity and vibration control required  
for measuring and viewing.

5.4.3 Heat problems caused by high intensity light sources.

5.4.4 Temperature and humidity control required on compressed  
air used for film cooling and air bearing stages.

5.5 Evaluate Film Base and Emulsion Stability as to:

5.5.1 Roll film vs chip storage

5.5.2 Sheet processing of duplicates for mensuration vs  
standard Niagria processing.

5.5.3 Measuring accuracy on original negative, first positive, etc.

5.5.4 Mensuration results on dry silver processed positive transparencies vs standard wet process.

## 6. Technical Requirements

It is realized that the complexity and emphasis will vary and be shifted with the findings of the basic research. The Objectives listed on Section 5 are very broad and within these areas the contractor will perform the following:

6.1 Provide consultation to the Government in the precise measurement field.

6.2 Have an expert awareness of past and present research in this field so as to prevent duplication.

6.3 Have the capabilities to undertake studies to determine the most desirable mensuration procedure for a task.

6.4 Be capable of undertaking practical experimentation as well as the theoretical approach on imagery measuring problems.

6.5 Be capable of determining the dynamic range capabilities and limitations of possible systems utilizing film inputs.

6.6 Conduct studies to determine the sub systems that require a major research effort.

6.7 Determine weak links in the mensuration process.

6.8 Generate Design Specifications that should be incorporated into immediate and future mensuration equipment.

6.9 Prepare Cost vs Performance Curves for various mensuration tasks, instruments, and the degree of precision required.

## 7. AREAS OF INVESTIGATION

7.1 The contractor will be able to obtain a great deal of information from the technical literature and government research programs referred to in Paragraph 5.1. The contractor will be expected to digest and present this information in a manner so that it can be implemented in future mensuration systems.

7.2 The contractor will have to supply his own photogrammetrists and interpreters for any tests and experiments he plans to perform. It is possible that some time on the Government's measuring instruments could be provided the contractor, however, it is recommended that he plan on supplying the majority of the instrumentation required on any tests.

7.3 The contractor is encouraged to undertake a limited amount of experiments, tests, and breadboarding in order to demonstrate any significant findings or breakthroughs.

7.4 The contractor will make recommendations as to improving mensuration techniques, equipment, and subsystems with the prospects for high payoffs:

- 7.4.1 Immediately
- 7.4.2 In the Near Future
- 7.4.3 In Long Range Mensuration Planning

7.5 The contractor is expected to supply recommendations, test results, and specifications as to pushing the state-of-the-art in developing mensuration equipment and procedures to extract the maximum data from the imagery, however he must primarily consider procedures to make the mensuration process more efficient, faster, and less costly while relieving the operational personnel of the drudgery and monotony of performing routine tasks.

## 8. Miscellaneous

### 8.1 Level of Effort

The available FY-1970 funding for this project is very limited, therefore, the areas to be investigated have been restricted to the most pertinent problem areas. This project is intended to be a 1-year level of effort to be completed under FY-1970 funds.

### 8.2 Proposals

The potential bidders are required to review the objectives and to isolate the areas they feel are most productive. The bidder's proposal will break the productive areas down into tasks and each task will be priced out separately in the proposal. The proposals should be comprehensive, well organized, explicit, clear, concise, and limited in content to that information required to qualify the prospective bidder and demonstrate ability to perform satisfactorily within the scope of this document. The format of the proposal should be arranged to separate company and personnel qualification sheets from the main body of the proposal.

### 8.3 Administration

The Government will retain overall control of this program. Written approval from the contracting officer must be obtained before any changes in objectives, costs, or priorities are effected or before any subcontractor or consultant is employed.

### 8.4 Contractor Responsibility

The contractor is expected to provide competent and cooperative administrative service. He will be vested with certain authority to control the direction and degree of technical effort within the bounds of the estimated costs. As a part of his overall responsibility, the contractor will be responsible for the work performed by all of his subcontractors and consultants. The fact that the Government has granted approval of the use of a specific subcontractor or consultant (see Paragraph 8.3.) in no way relieves the contractor from this responsibility.

### 8.5 Technical Representatives

The contracting officer will designate a technical representative to authorize specific development efforts of the contractor. Such authorization shall be given in writing in its original form or in confirmation of an oral authorization. The contractor will accept no other authorization except that of the technical representative or contracting officer.

### 8.6 Reports

Regular reports will be required throughout the life of the contract. All reports will meet the basic requirements of specification DB-1001, dated 31 August 1966, GENERAL REQUIREMENTS FOR CONTRACTUAL DOCUMENTATION, attached hereto.